

SELECTION DEVICE FOR A SEMICONDUCTOR MEMORY DEVICE

5 Cross-Reference to Related Application:

This application is a continuation of copending International Application No. PCT/DE02/00141, filed January 18, 2002, which designated the United States and was not published in English.

10 Background of the Invention:

Field of the Invention:

The invention relates to a selection device for a semiconductor memory device or the like having, for each selectable access line device, particularly, for each bit line device, for accessing storage elements in the memory area of the semiconductor memory device that are connected to the respective selectable access line device, a respective associated switching device. The switching device can controllably connect the respective associated access line device, upon selection, to a sense-amplifier device, specifically, to a potential-sensing connection on the sense-amplifier device for detecting the electrical potential on the respective access line device and to a current-supply connection on the sense-amplifier device for supplying a compensating current to the respective access line device.

Modern semiconductor memory devices have a memory area containing a plurality of storage elements or memory cells. The storage elements or memory cells are, in this case, often produced in a matrix-like configuration and can be addressed 5 using access line devices, for example, bit lines and word lines, in order to read and/or alter the storage state or information state of each storage element or each memory cell.

In this context, addressing and, hence, access are normally 10 effected using appropriate selection devices based upon a row selection, for example, for the word lines, and by a column selection, for example, for the bit lines. In this case, the system of memory cells disposed in matrix form and of selected and unselected access lines forms a network of non-reactive 15 resistances, with the cell resistances of the individual storage elements or memory cells needing to be taken into account in particular.

By selecting a corresponding word line and a corresponding bit 20 line, the intention, particularly, for reading, is to address precisely one well-defined memory cell or one well-defined storage element. On account of the network-like interconnection of the plurality of memory cells or storage elements in the memory area, however, not only the signal 25 representing the storage state of the addressed cell but also "parasitic signals" from the unselected storage elements or

memory cells and/or the corresponding access lines arise. These parasitic signals are superimposed on the actual signal to be detected and analyzed from the selected cell and can result in corruptions.

5

To suppress these parasitic signals or to reduce their influence, use is normally made of a sense-amplifier device that can keep the potential difference across the unselected memory area and the related electric current as small as possible, but at least constant, so that the signal to be detected from the selected cell, particularly, in the case of MRAM cells based on a "cross-point configuration," can be distinguished from the parasitic signals.

15 The problem with conventional selection devices is that, under real conditions for the read operation, particularly, in MRAM cells, the reading current through the plurality of disconnected switching elements, particularly, in the form of transistor devices or the like, results in voltage drops, 20 which means that the voltage or the potential on the access line device or bit line to be read cannot be regulated to the correct value by the sense-amplifier device.

Summary of the Invention:

25 It is accordingly an object of the invention to provide a selection device for a semiconductor memory device that

overcomes the hereinbefore-mentioned disadvantages of the heretofore-known devices of this general type and in which operating faults as a result of the voltage drops caused by reading currents can be avoided particularly easily and,  
5 nonetheless, reliably.

With the foregoing and other objects in view, in a semiconductor memory device having a memory area with storage elements, selectable access line devices respectively  
10 connected to the storage elements, and a sense-amplifier device with a potential-sensing connection and a current-supply connection, there is provided, in accordance with the invention, a selection device including switching devices each associated with and connected to a respective one of the  
15 access line devices for accessing the storage elements in the memory area, each of the switching devices controllably connecting, upon selection, the respective associated access line device to the potential-sensing connection for detecting an electrical potential on the respective access line device  
20 and to the current-supply connection for supplying a compensating current to the respective access line device and having first and second switching elements and, during operation, the first switching element connecting the associated access line device to the potential-sensing  
25 connection and the second switching element connecting the

associated access line device to the current-supply connection.

With the objects of the invention in view, there is also  
5 provided a semiconductor memory device, including a memory  
area having storage elements, selectable access line devices  
respectively connected to the storage elements, a sense-  
amplifier device having a potential-sensing connection and a  
current-supply connection, the sense-amplifier device  
10 connected to the access line devices, and a selection device  
having switching devices each associated with and connected to  
a respective one of the access line devices for accessing the  
storage elements in the memory area, each of the switching  
devices controllably connecting, upon selection, the  
15 respective associated access line device to the potential-  
sensing connection for detecting an electrical potential on  
the respective access line device and to the current-supply  
connection for supplying a compensating current to the  
respective access line device and having first and second  
20 switching elements and, during operation, the first switching  
element connecting the associated access line device to the  
potential-sensing connection and the second switching element  
connecting the associated access line device to the current-  
supply connection.

Preferably, the access line devices are bit line devices and the switching devices are each associated with and connected to a respective one of the bit line devices.

- 5 The generic-type selection device for a semiconductor memory device or the like has, for each selectable access line device, particularly, for each bit line device or the like, for accessing storage elements in the memory area of the semiconductor memory device that are connected to the
- 10 respective selectable access line device, a respective associated switching device or the like. In such a case, during operation, the switching device can controllably connect the respective access line device, upon selection, to a sense-amplifier device, specifically, to a potential-sensing
- 15 connection on the sense-amplifier device for detecting the electrical potential on the respective access line device and to a current-supply connection on the sense-amplifier device for supplying a compensating current to the respective access line device.
- 20 In the case of the inventive selection device, each switching device has a first and a second switching element, respectively. During operation, the first switching element can connect the associated access line device to the
- 25 potential-sensing connection on the sense-amplifier device. In addition, during operation, the second switching element can

connect the associated access line device to the current-supply connection on the sense-amplifier device.

In the case of conventional selection devices, each selectable access line device, particularly, a bit line or the like, is substantially provided with a single switching element. This single switching element conventionally connects the respective associated access line device as a whole to the potential-sensing connection and, at the same time, to the current-supply connection on the associated sense-amplifier device. In the case of the conventional configuration, during operation in the real instance of application, a certain reading current, which results in an uncontrollable voltage drop across the entire selection device that cannot be corrected overall by the sense-amplifier device, also flows through the disconnected switching elements, e.g., through switching transistors. Consequently, in the case of conventional selection devices, the connected sense-amplifier devices cannot maintain any defined voltage at the end of the respective selected bit line devices.

With the inventive procedure, on the other hand, two switching elements are provided, the first switching element being able to set up a respective connection to the potential-sensing connection, and the second switching element being able to set up, in parallel therewith, a connection to the current-supply

connection on the sense-amplifier device. If the access line device is selected, i.e., the bit line is selected, the first switching element is connected, and contact with the potential-sensing connection on the sense-amplifier device is

5 set up. Because potential-sensing connections are of relatively high-impedance design, substantially no reading current flows through the closed first switching element, which means that the magnitude of the resistance of the first switching element and, hence, the voltage drop across it are

10 insignificant. The potential-sensing connection can, thus, exactly detect the electrical potential that is present at the end of the access line device, particularly, the bit line device.

15 As a result of the second switching element provided in parallel therewith, which is, likewise, connected or closed upon selection, the connected sense-amplifier device uses the appropriate connection to readjust the compensating current until the potential difference detected through the first,

20 closed switching element assumes the correct value. The resistance of the second switching element is, thus, likewise of virtually no significance, because its influence can just be corrected through the sense-amplifier device. The compensating current impressed by the sense-amplifier device

25 is evaluated and reflects the respective programming state

read from the selected memory cell or from the selected storage element.

The fundamental idea of the present invention is, thus, to  
5 produce, in the selection device, two switching elements connected in parallel with one another for making contact with the potential-sensing connection, on one hand, and with the current-supply connection, on the other hand, so that the voltage drops across the non-reactive resistances of the  
10 switching elements can be corrected based upon the regulating mechanism and have no significance at all.

To such an end, in accordance with another feature of the invention, the first and second switching elements provided  
15 are, respectively, in a form connected substantially in parallel with one another.

In addition, in accordance with a further feature of the invention, particularly simple operation of the inventive  
20 selection device results if the switching elements can each produce substantially two switching states, particularly, a connected or contact-making switching state and a disconnected or isolating switching state, respectively.

25 Particularly reliable regulation or particularly little influence for the non-reactive resistances of the switching

elements is obtained if, in the first, connected or contact-making state, the first switching element can make comparatively low-resistance contact, particularly, with the potential connection on the sense-amplifier device, the lower 5 resistance being compared to a contact of the second switching element.

In accordance with an added feature of the invention, the inventive selection device has a particularly simple form if 10 the switching elements are in the form of transistor devices, particularly in the form of MOSFETs, or the like.

In this context, in accordance with an additional feature of the invention, provision is, preferably, made for respective 15 drain regions of the transistor devices to be in a form connected to the associated access line device. In addition, provision is made for respective source regions of the transistor devices to be in a form connected to the respective potential-sensing connection or to the current-supply 20 connection on the associated sense-amplifier device.

In principle, each access line device, particularly, each bit line device, can be associated with a respective separate sense amplifier device so that each switching device also 25 selects a corresponding sense-amplifier device upon selection of the corresponding associated access line devices.

On the other hand, a particularly space-saving configuration is obtained if, in accordance with a concomitant feature of the invention, the plurality of output connections, 5 particularly, of source regions, on the first and second switching elements are, respectively, connected to a common line device and, through the latter, to a common sense-amplifier device.

10 All in all, this means that a single, common sense-amplifier device can read a plurality of selectable access line devices. The common line devices, then, firstly connect the output connections of the first switching elements jointly to the single potential-sensing connection on the common sense-amplifier device. Secondly, the second common line device 15 connects all the output connections of the second switching elements to the common current-supply connection on the common sense amplifier. This means that, all in all, the thus organized group of memory cells or selectable access line 20 devices requires a total of just one single sense-amplifier device.

Other features that are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a selection device for a semiconductor memory device, it is, nevertheless, not intended to be limited to the details shown because various modifications and structural 5 changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, 10 however, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

15 Brief Description of the Drawings:

FIG. 1 is a schematic and block circuit diagram of a basic configuration of a memory device with the selection device according to the invention; and

20 FIG. 2 is a schematic and block circuit diagram of details of a connection of the selection device of FIG. 1.

Description of the Preferred Embodiments:

Referring now to the figures of the drawings in detail and 25 first, particularly to FIG. 1 thereof, there is shown a schematic circuit configuration for the basic configuration of

a semiconductor memory device 1 using an embodiment of the inventive selection device 10.

The semiconductor memory device 1 has a memory area 2. This 5 includes a matrix-like configuration of memory cells 3 and 3', the memory cells or storage elements 3' not being selected for reading in the state of the semiconductor memory device 1 that is shown in FIG. 1. By contrast, the storage element 3 in the memory area 2 has been selected for reading. For such 10 selection, the word line WLi together with the bit line BLk of the access line devices 6 and 4 are realized by corresponding switching states of the row selectors or multiplexers 8 and column selectors or multiplexers 7 in FIG. 1. Both the row selectors and the column selectors 8 and 7 can be of the 15 configuration described in line with the invention.

The selected word line WLi is at the word line voltage or reading voltage Vwl. All of the unselected word lines or bit lines of the access line devices 6 and 4 are at the 20 equipotential voltage or equalization voltage Veq. Ideally, the equipotential voltage Veq is also present on the selected bit line BLk at its end, namely, at the node 7a and, thus, at the potential-sensing connection 22 on the sense-amplifier configuration 20.

FIG. 1 particularly shows the interconnection for reading a cross-point MRAM memory matrix. The configuration in FIG. 1 also shows that the non-reactive resistances RC1 and RC2 in the corresponding memory cells 3' conduct no parasitic currents that can disturb the reading signal for the selected memory cell 3 with its non-reactive resistance RC. The currents through RC3 also do not result in any fundamental disturbance of the reading signal.

FIG. 1 also shows that the column multiplexer 7 shown or the selection device 10 for the bit lines BLj can, respectively, connect a particular bit line BLk in the memory device 1 to the input 22 of the sense-amplifier device 20.

In conventional configurations, it is not possible to connect an appropriate number of switching elements or switch transistors, namely, corresponding to the number of selectable access line devices or bit lines, for the column multiplexer simply between the bit lines of the MRAM array and the input of the sense amplifier 20. This is because the reading current would, then, need to flow through the respective switch transistors and would result in an uncontrollable voltage drop that would not be able to be corrected by the sense amplifier 20. Hence, in conventional configurations, no defined voltage would become established at the end of the selected bit line BLk or would be able to be kept by the amplifiers 20.

FIG. 2 uses a schematic circuit diagram to show an embodiment of the inventive selection device 10 when used in a semiconductor memory device 1.

5

The memory area 2 of the semiconductor memory device 1 has a memory cell 3 selected for reading and also unselected memory cells 3'. The non-reactive resistances existing in connection with these selected and unselected memory cells 3 and 3' are 10 denoted by  $RC$  and  $R_{par}'$ . The electrical currents flowing through the selected and unselected memory cells 3 and 3' are referred to as cell current  $I_c$  and parallel current  $I_{par}'$ .

In this case, the connected selection device 10 is in the form 15 of a column selection device 7. In FIG. 2, only the switching device 12 for selecting the  $k$ th bit line  $BL_k$  is shown. The corresponding switching elements  $T_1$ ,  $T_2$  are in the form of MOSFETs and have drain regions  $D_1$ ,  $D_2$ , source regions  $S_1$ ,  $S_2$ , and gate regions  $G_1$  and  $G_2$ .

20

The first and second switching elements  $T_1$  and  $T_2$  are connected in parallel with one another from the node 12a. The drain regions  $D_1$  and  $D_2$  are connected directly to the  $k$ th bit line  $BL_k$  in the configuration. The source regions  $S_1$  and  $S_2$  of 25 the switching elements  $T_1$  and  $T_2$  are connected to the potential-sensing connection 22 and to the current-supply

connection 24, respectively, on the sense-amplifier device 20. The connection 21 is used to supply the equalization voltage or equipotential voltage  $V_{eq}$ . The output 23 of the sense-amplifier device 20 is used to provide the evaluated reading 5 signal  $V_{out}$ , which represents the information or storage state of the selected memory cell 3.

The bit line  $BL_k$  to be read in the memory area 2 itself is shown here in the form of a series circuit including the 10 corresponding resistances  $R_{par'}$  and  $R_C$ . In comparison with FIG. 1,  $R_C$  is shown to be the non-reactive resistance of the selected memory cell 3. This resistance is connected to ground through the word line voltage or reading voltage  $V_{wl}$  by the selected bit line  $BL_k$ .

15 FIG. 2 shows that the selected bit line  $BL_k$  is connected to the sense-amplifier device 20 through the switching transistors  $T_1$  and  $T_2$  as first and second switching elements. In more complex memory configurations, it may be necessary for 20 the switching transistors  $T_1$  and  $T_2$  each to be formed also by a more complex series circuit including a plurality of transistor devices. The number of transistors that needs to be used as a series circuit for  $T_1$  and  $T_2$  is of substantially no significance for the manner of operation of the inventive 25 principle presented here, however.

In line with the invention, the switching elements T1 and T2, particularly, the corresponding transistor devices T1 and T2, have the following effect: the input, namely the potential-sensing connection 22, of the sense-amplifier device 20 is connected directly to the end of the selected bit line device BLk through the transistor device T1. The sense-amplifier device 20 can, thus, sample and ascertain the voltage  $V_{sense}$  that is present on the selected bit line BLk directly. The non-reactive resistance of the switching element or of the transistor device 1 has no significance on account of the relatively high input resistance of the potential-sensing resistance 22 of the sense-amplifier device 20 because no significant current flows through the switching element T1, i.e.,  $I_{sense}$  is substantially equal to zero.

Through the second switching element or the second transistor device T2, the sense-amplifier device 20 uses the current-supply connection 24 to readjust the voltage  $V_{force}$  applied thereto, the supply current or the compensating current  $I_{comp}$  or  $I_{force}$  until the correct voltage is detected on the selected bit line BLk through the first switching element or the first transistor device T1 and is set.

Consequently, the non-reactive resistance of the second switching element T2 is also irrelevant in this context because its influence is directed by the sense-amplifier

device 20. The compensating current or supply current  $I_{comp}$ ,  $I_{force}$  is evaluated by the sense-amplifier device 20 and substantially represents the programming state or storage state read for the selected memory cell 3.

5

The inventive circuit illustrated, thus, makes it possible to provide a selection device 10, particularly a column multiplexer 7, in which voltage drops across the switching elements or switching transistors T1 and T2 that could be 10 brought about by reading currents  $I_{sense}$  flowing have no significance.